

Observations of C-Band Brightness Temperature from the Hurricane Imaging Radiometer (HIRAD) on board NASA WB-57 during GRIP in Hurricanes Earl and Karl (2010)



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Hurricane Imaging Radiometer (HIRAD)

HIRAD Physical Principles

HIRAD Technology Investment Roadmap

HIRAD Passive Microwave C-Band Radiometer :

- Version 1:** H-pol at 4, 5, 6 & 6.6 GHz freq for wind speed and rain rate
- Version 2:** H- & V-pol continuum of C-band freq for Ocean Surface Vector Wind (OSVW) & rain rate

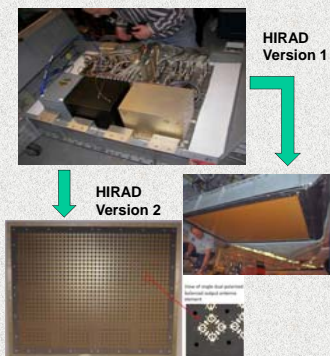
Performance Characteristics:

- Earth Incidence angle: 0- 60° ,
- Spatial Resolution: 2-5 km,
- Swath: ~70 km for 20 km altitude

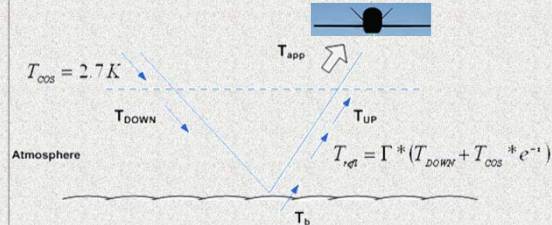
Observational Goals:
WS: 10 to >85 m/s; RR: 2 to > 100 mm/hr

HIRAD advances:

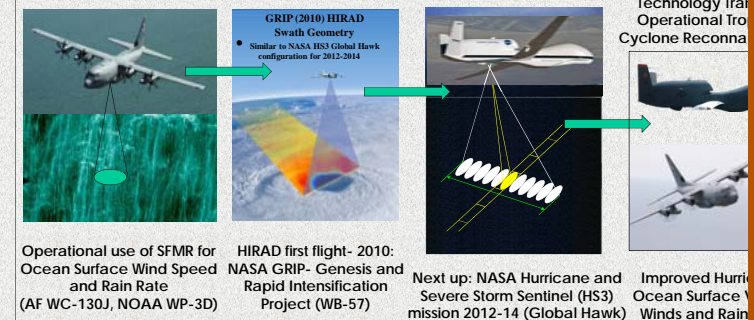
- Expands Stepped Frequency Microwave Radiometer (SFMR) coverage from nadir to wide swath
- Eliminates SFMR max wind under-sampling with wide-swath sampling of entire eyewall (instantaneously)
- Uses synthetic thinned array and RFI mitigation technology of Lightweight Rain Radiometer (NASA Instrument Incubator)



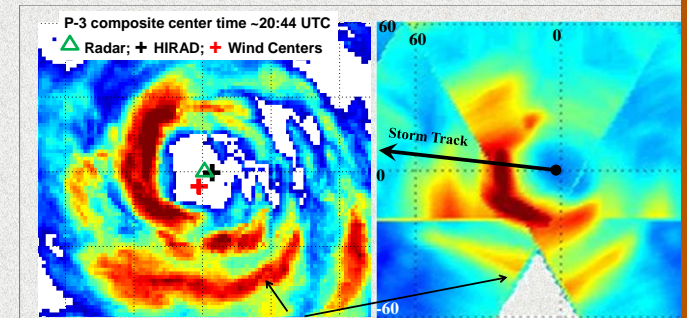
- A continuum of frequencies rather than 4 discrete ones will result in more accurate wind speed retrievals and with dual-polarization: wind direction retrievals as well (OSVW).
- It will also eliminate wind and rain retrieval ambiguities in gale-force wind regimes.



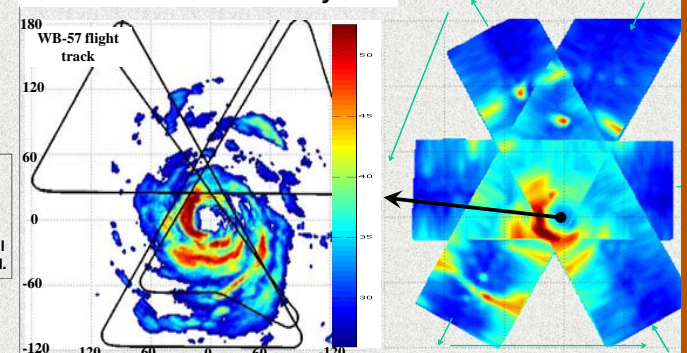
- HIRAD measures 'emissivity' over a range of incidence angles and frequencies from ocean surface foam (a function of wind speed) and intervening rain.
- At C-band microwave frequencies (4-6.6 GHz), emissivity from wind-driven foam is invariant with frequency while rainfall emissivity is a strong function of frequency.
- These physical characteristics allow two geophysical variables (wind speed and rain rate) to be derived from emissivity measurements at 4-6 discrete C-band frequencies, an 'over-determined', 'least-squares' problem solvable with conventional mathematical techniques.
- Surface wind speed and rain rate retrievals are derived from empirical correlation of HIRAD measured emissivity at operating incidence angles with co-located GPS dropsonde surface wind observations and accepted functional relations for rain attenuation vs frequency.



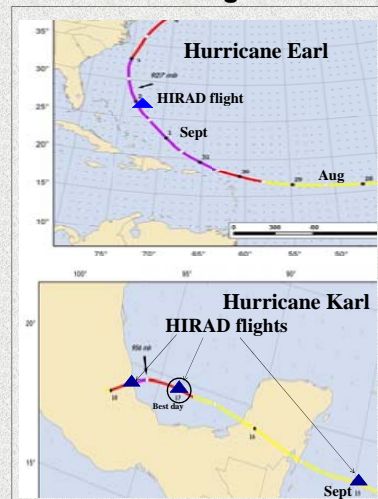
Karl 16 Sept 2010



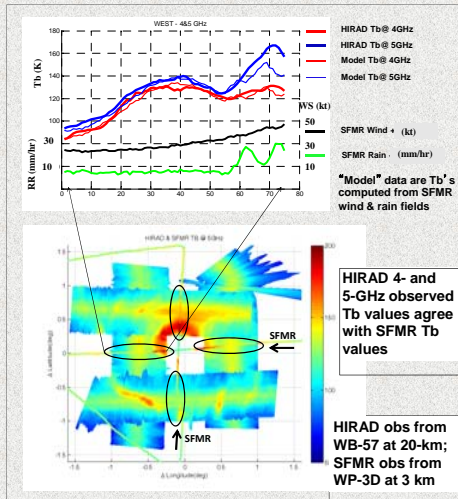
WP-3D LF radar reflectivity dBZ HIRAD 5 GHz excess Tb



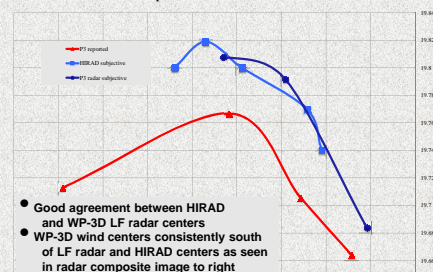
Earl and Karl Storm Tracks: HIRAD WB-57 Flight Locations



Earl Flight: 1-2 Sept 2010



Karl 16 Sept Center Position



- Key features of radar and HIRAD comparison (right):**
- 1) Eyewall dBZ and HIRAD Tb maxima are located in left-front quadrant. This, together with open eyewall in right-rear quadrant, suggest easterly environmental shear.
 - 2) Partial outer concentric eyewall is suggested equally well in radar and HIRAD images, as is outer principal rainband.

HIRAD GRIP Calibration Challenges

- Rain rate and wind speed retrievals to be based on three calibrated frequencies: 5 GHz T_b (Microwave Brightness Temperature) have been successfully produced
- Calibration of other 2 channels is in progress; completion within 3 months
- HIRAD calibration issues and mitigation for HS3:
 - Calibration uses internal reference blackbody targets and noise diodes
 - Calibration algorithm depends on reference T_b ; uncorrected instrument temperature dependence found during GRIP flights (+/-25° C)
 - Temperature correction algorithm being developed for GRIP (requires additional instrument characterization testing)
 - Thermal control subsystem has been upgraded for HS3 to minimize instrument temperature fluctuations